NASA Datalink Communications Research & Technology Development For Aeronautics

Workshop for Integrated CNS Technologies

for

Advanced Future Air Transportation Systems

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Cleveland, Ohio

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NASA Technology Goals

NASA Technology Goals:

- *Safety:* Reduce the aircraft accident rate…
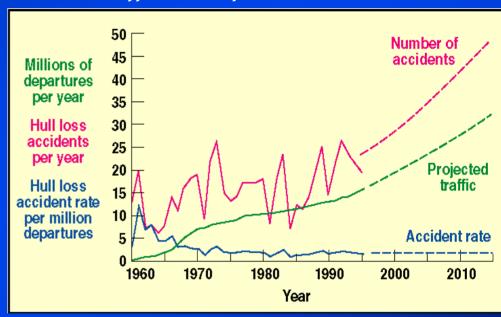
Aviation Safety

"Enable graphical weather in the cockpit"

- *Capacity*: Increase the aviation system throughput…

Aviation System Capacity

"Enable broadband communications for Free Flight"

Air Traffic to Triple in Next 20 Years

- *Mobility:* Reduce public travel times…

Small Aircraft Transportation System

"Enable an airborne internet for SATS"
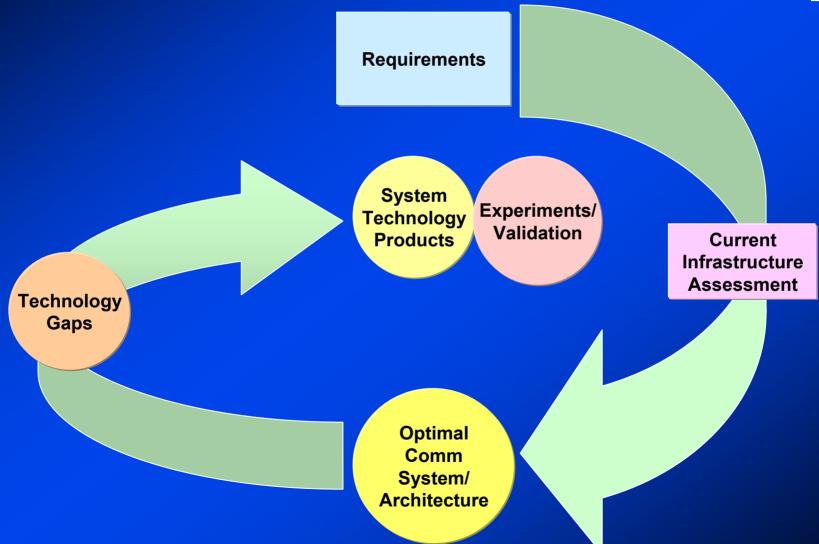
Technology Investment Areas

- Datalink Requirements & Architecture Analyses:
  - Mid-Term (2010)
  - Far-Term (>2020)

- Air/Ground Datalinks
  - Ground-based (terrestrial)
  - Satellite-based
  - Airborne-based

- Network Technologies
  - Aeronautical Telecommunications Network (ATN)
  - Internet Protocol (IP)

(Focus: Commercial Air Transport and General Aviation)

Development Approach

Requirements

System Technology Products

Experiments/ Validation

Current Infrastructure Assessment

Technology Gaps

Optimal Comm System/ Architecture

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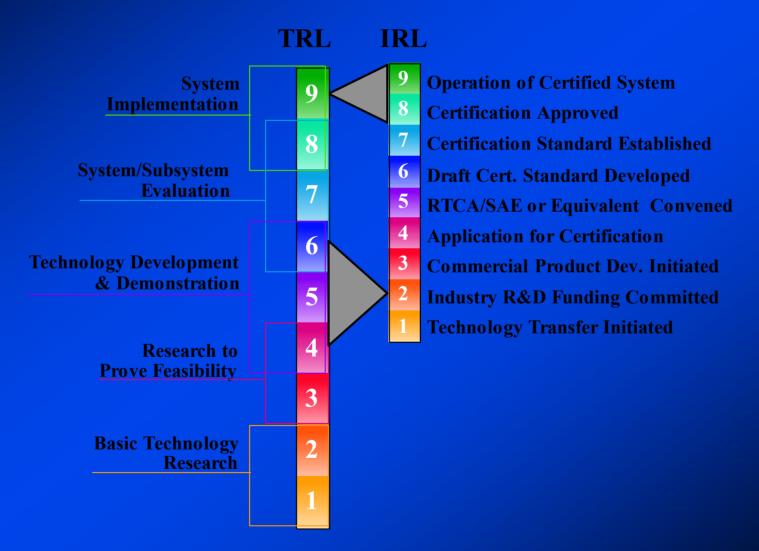
Technology & Implementation Readiness

TRL

IRL

System Implementation — 9

System/Subsystem Evaluation — 8, 7

Technology Development & Demonstration — 6, 5

Research to Prove Feasibility — 4, 3

Basic Technology Research — 2, 1

9 — Operation of Certified System
8 — Certification Approved
7 — Certification Standard Established
6 — Draft Cert. Standard Developed
5 — RTCA/SAE or Equivalent Convened
4 — Application for Certification
3 — Commercial Product Dev. Initiated
2 — Industry R&D Funding Committed
1 — Technology Transfer Initiated

NAS Information Exchange
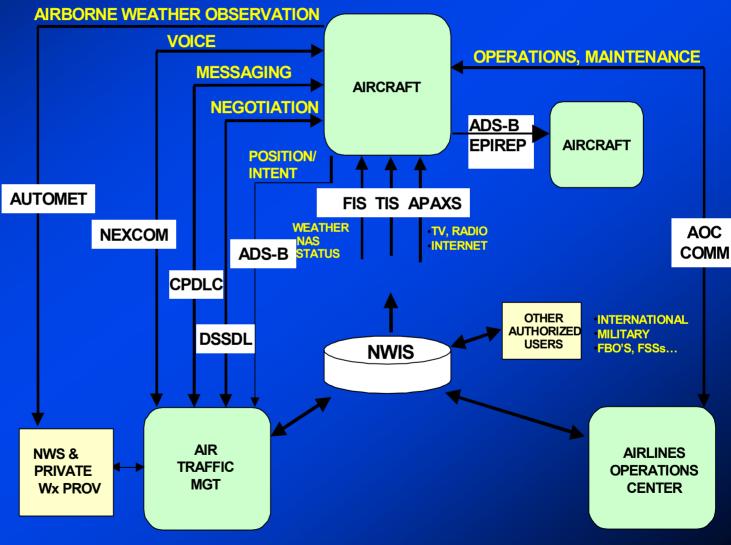
Options:

- Analog Voice
- ACARS
- VDL Modes 2-4
- Mode S
- UAT
- SATCOM
- HFDL
- Commercial
- Proprietary Links

Air Transport: Ground-based Datalinks

FedEx MD-11

USAF C-135C

Boeing Transport Cooperative Agreement

Honeywell Transport Cooperative Agreement

- Phase I (FY98-00) efforts (Boeing & Honeywell) utilized off-the-shelf comm for rapid implementation (air phone, VHF/ACARS, …)

- Optimal long-term operational end-solution may differ (VDL Mode 2, SATCOM)

- Recent In-Service-Eval's (ISE) of HI system by UAL (Electronic Flight Bag concept)

Air Transport: Ground-based Datalinks

NASA Langley B757 Aircraft

• Grants with Ohio University to assess addressed VDL-Mode 2 datalink for weather dissemination.

• VDL Mode 2 is future upgrade to ACARS

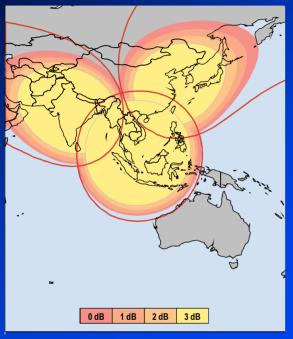• Laboratory and initial flight testing by Ohio U (Piper Saratoga).

• Partnering with ARINC to jointly evaluate VDL-2 datalink performance for FIS (Weather) applications.

• Experiments will include both signals-in-space as well as network characterization (ATN).

• Hardware will be integrated on NASA B-757 research aircraft for upcoming flight experiments with ARINC ground-system.

Air Transport: Satellite-based Datalinks

AsiaStar Antenna Beam Coverage

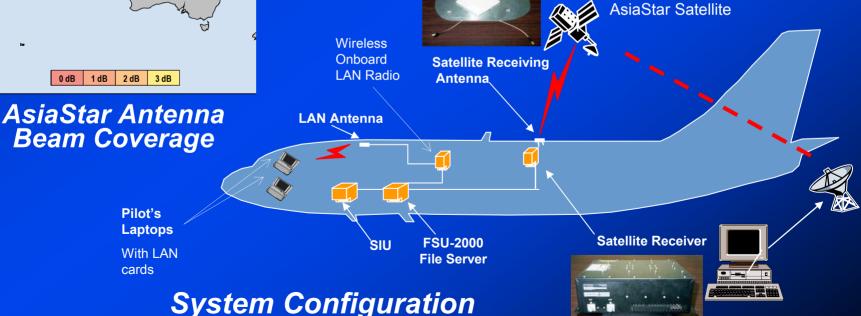| 0 dB | 1 dB | 2 dB | 3 dB |

Worldwide Transport

Operational Evaluation: American Airlines Operational B-777's Flying Chicago-Tokyo and Chicago-Hong Kong Routes Beginning Summer 2001

WorldSpace AsiaStar Satellite

Wireless Onboard LAN Radio

Satellite Receiving Antenna

LAN Antenna

Pilot's Laptops

With LAN cards

SIU

FSU-2000 File Server

Satellite Receiver

System Configuration

Air Transport: Satellite-based Datalinks

- Enabling technologies:
  - Phased array antennas
  - Broadband mobile terminal

- Joint NASA/Boeing development

- Up to 1000x capacity increase
  - 256 Kbps off aircraft
  - 2.18 Mbps to aircraft

- Ground-mobile experiments

- Proof flight test Dec, 2000 (DC-8)

- Upcoming B-757 experiments

- Enabling to *Connexion by Boeing*

GE-2
DC-8
GRC
DFRC
ARC

General Aviation: Ground-based Datalinks

- Cooperative NASA research with ARNAV and Honeywell (NavRadio)

- VHF-based broadcast & 2-way datalinks
  - VDL-Mode 2
  - GMSK

- Addresses near-term need for broadcast of graphical weather to the G/A cockpit

- Resulting FAA/industry implementation:
  - G/A focused service volume
  - Dual vendors (ARNAV & Honeywell)
  - 5 year FAA contract (FY00-04)
  - 2 national frequencies per vendor
  - Free text weather products
  - Fee-based value/graphical products
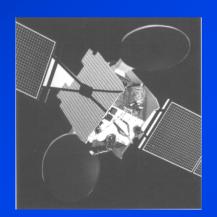
17,500 Ft. MSL

Altitude Coverage

5,000 Ft. AGL

General Aviation: Satellite-based Datalinks

Flight test and evaluation of worldwide weather datalink capability using broadcast Satellite Digital Audio Radio Services (S-DARS).

Johannesburg, South Africa

September, 1999

Internal Equipment (GPS, Laptop Computer, etc.)
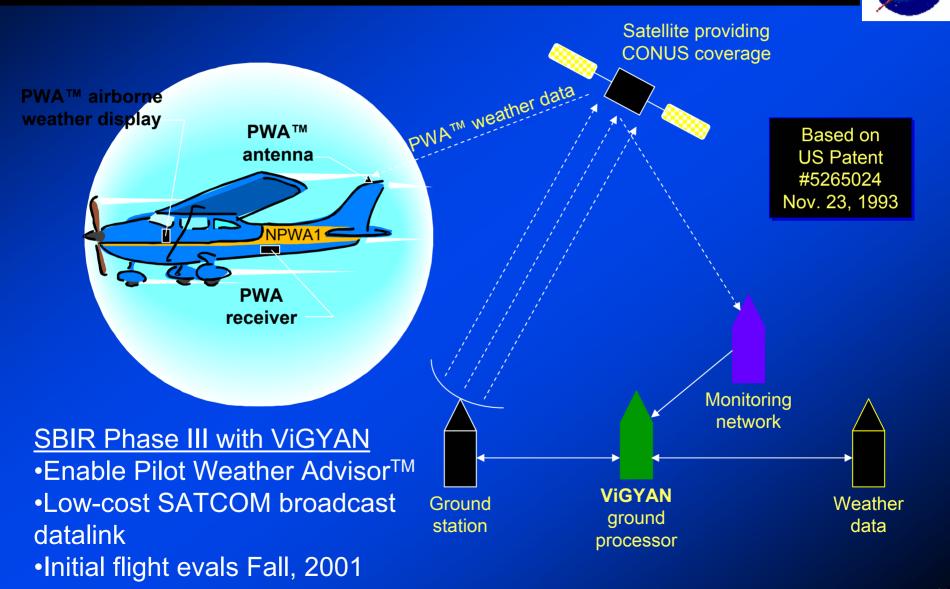
Satellite

Receiver

AfriStar Satellite

Patch Antenna Mounted to Cessna 172

General Aviation: Satellite-based Datalinks

Satellite providing CONUS coverage

PWA™ airborne weather display

PWA™ antenna

PWA™ weather data

NPWA1

PWA receiver

Based on US Patent #5265024 Nov. 23, 1993

Monitoring network

SBIR Phase III with ViGYAN
• Enable Pilot Weather Advisor™
• Low-cost SATCOM broadcast datalink
• Initial flight evals Fall, 2001

Ground station

ViGYAN ground processor

Weather data

Low-Altitude AutoMET Reporting

- Use aircraft operating below 20,000 ft altitude to sense and report
  - Moisture
  - Temperature
  - Winds

- To be used by:
  - Forecast models
  - Weather briefers
  - Controllers
  - Other aircraft

- Investigating numerous airborne-based datalinks and architectures for technical feasibility

MDCRS & AMDAR Coverage from Transports

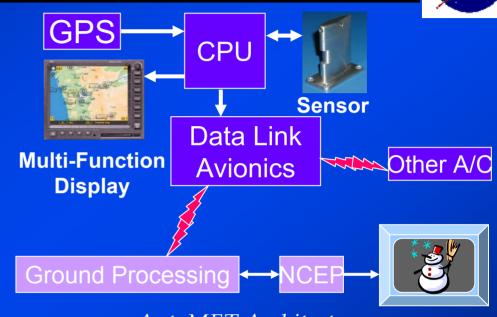**20,000 ft. MSL**

AutoMET Coverage

Ground Level

AutoMET: Airborne-based Datalinks

Airborne-based Datalinks:

•Extension of MDCRS service (ACARS/ARINC)

•VHF/GMSK (ARNAV Systems)

•VDL-Mode 2 (ARINC & HI)

•UAT (FAA Capstone & UPSAT)

•Satellite (OrbComm, others)

•ADS-B Datalinks (JH/APL)

AutoMET Architecture
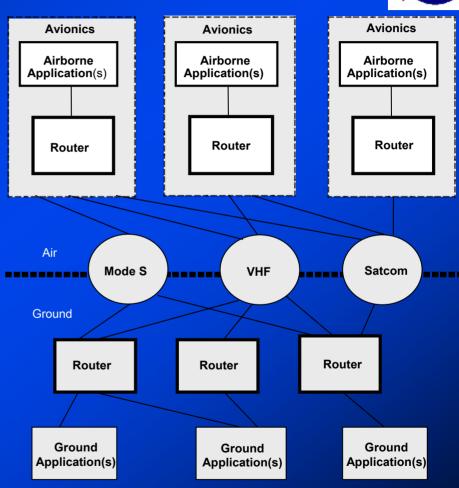

NASA Cessna 206

Network Protocols Development

- Collaborative tasks with MIT/Lincoln Laboratory for FIS/Weather:

  - ATN and Internet Protocol (Mobile IP) network feasibility

  - IP-over-VDL Mode 2 datalink interface definition

- Joint NASA/ARINC research on IP over VDL-Mode 2 datalink for FIS

- ATN over broadband SATCOM feasibility (Space Act Agmt w/ATNSI)

- Next-generation Mobile IP research for aeronautical app's (CNS, Inc.)

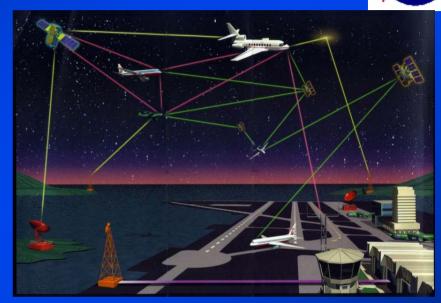**Network Routing Connectivity**

FAA/NASA Alliance

- FIS Datalink & Weather Requirements Offices (AUA & ARW)
    - Co-funded tasks under NASA/FAA Memo of Agreement:
    - Low-altitude AutoMET datalink technical architecture alternatives
    - FIS/Weather datalink technical architecture analyses:
        - Mid-Term (2004-2007)
        - Far-Term (2010 and beyond)
    - Terminal area weather datalink communications alternatives

- Office of Architecture and System Engineering (ASD)
    - Joint Research Project Definitions (JRPDs):
    - FIS and ATM datalink architecture analyses
    - Terminal area broadband communications

- CAPSTONE Program (Alaska)
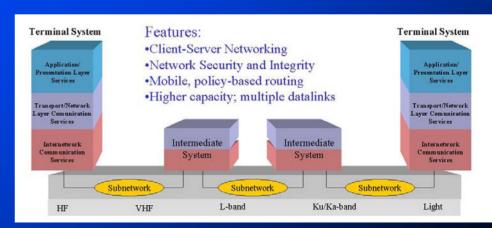   - UAT datalink investigation for AutoMET; SATCOM augmentation

New Activity: SATS Airborne Internet

- A communications architecture for internet-like information delivery

  - Aircraft and ground facilities are interconnected nodes on a high-speed digital network

  - Open standards and protocols

- A network management system that provides:

  - Mobile and policy-based routing

  - Service priority communications

  - Interface to onboard aircraft subnet(s)

  - Secure network communications

  - Point-to-point, point-to-multipoint, and broadcast addressing

- A communications management system for integrating multiple CNS datalinks and sensors.

(Illustration courtesy of Rockwell-Collins)

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Observations, Questions and Issues

- There is a great need for an <u>integrated systems</u> approach to developing CNS systems
  - Technology development
  - Modernization

- Spectrum management:
  - Enough spectrum capacity for the far-term?
  - Non-aviation threats to aviation spectrum

- There is a need for CNS systems modeling and simulation capability

- The VDL Mode 2 / Mode 3 / 8.33 debate: is there a need for NASA technical involvement? Technical issues to address?

- Should NASA focus only on far-term (>2020), mid-term (2010), both ?

Observations, Questions and Issues

- What's the future of IP and ATN in aviation? Where should NASA's communications network research focus?

- Aviation community needs to advocate CNS much more strongly for both
  – Technology development and validation
  – Modernization efforts